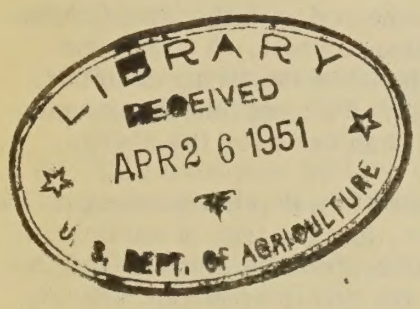
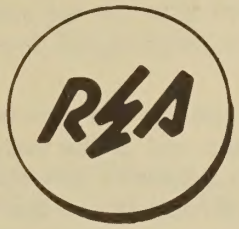
EXPLOSIVES FOR DIGGING POLE HOLES





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U. S. DEPARTMENT OF AGRICULTURE
RURAL ELECTRIFICATION ADMINISTRATION
TECHNICAL STANDARDS DIVISION

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FOR
DIGGING POLE HOLES

INTRODUCTION

REA is directly interested in any method or device which will reduce the time and cost of building transmission and distribution lines. Therefore, when information was received concerning two new methods of digging pole holes which perhaps would reduce the cost of this operation an investigation was started. The suggested new methods of digging pole holes were (1) using a Shaped Charge for blasting the hole and (2) using a Blast Driven Earth Rod to bore the hole and primacord for enlarging it. Each method has been investigated from the standpoint of possible use by REA-financed cooperatives and the following information has been compiled.

BLAST DRIVEN EARTH ROD

A. Origin and Description

The Blast Driven Earth Rod was designed originally in Germany for digging post holes and later developed by the U. S. Army Engineers. It consists of three main and two auxiliary parts. The main parts are: (1) a steel rod 6 feet long by 1-1/4 inches in diameter, threaded at one end; (2) an open cylindrical steel firing chamber 15 inches long and 4-1/2 inches in diameter which screws onto the top of the rod; and (3) a 1-1/2 inch diameter conical shaped expendable steel point which slips over the bottom of the rod. The auxiliary parts are: (1) a short piece of steel rod used to start the point into the ground, and (2) a tool resembling a jack which is used to pull the rod out of the ground after the blast.

B. Procedure

The point is first driven about 6 inches in the ground and the rod with the firing chamber attached is inserted into the open end of the conical shaped point. A 1/2 pound charge of commercially prepared smokeless powder is placed in the firing chamber and the fuse with a squib attached is inserted in the charge. To complete the preparation, variable amounts of sand or earth are placed in the chamber over the charge.

When the explosive is fired the shaft is driven in the ground to a depth depending on the amount of explosive, the weight of the soil in the chamber, and the type of earth being penetrated. Rocks as large as 8 or 10 inches in diameter sometimes stop the rod, but smaller rocks are usually pushed aside. After the blast the rod is removed, leaving the point in the ground. Strands of primacord are lowered into resulting hole and detonated expanding the hole uniformly, the amount of expansion depending on the number of strands of primacord used. Ordinarily one strand of primacord enlarges the hole by one inch in diameter; however, this will vary with soil conditions.

C. Discussion

On September 16, 1949, personnel from REA witnessed a demonstration of the Blast Driven Earth Rod at Ft. Belvoir, Virginia. The device was set up and fired first in ordinary soil then in rather hard earth containing rock. The result in the ordinary soil

was a hole 6 feet deep by 1-1/2 inches in diameter which was enlarged to approximately 10 inches in diameter by lowering 8 strands of primacord into the hole and detonating it. The results in the hard earth containing rock were indicative at least. The rod was propelled down about 3 feet where its progress was interrupted by a rock.

More extensive tests have been made by the Corps of Engineers in various soil types and they report that the Blast Driven Earth Rod will give consistent penetration of 4 to 6 feet unless large rocks are encountered.

D. Cost

The Blast Driven Earth Rod is not being manufactured at this time; therefore, price information is not available. During World War II the device was manufactured by the Rock Bit Sales and Service Company, Philadelphia, Pennsylvania. The propellent Charge, squib, and cap were manufactured by the Hercules Powder Company, Wilmington, Delaware. Detonating cord is manufactured by the Ensign Bickford Company, Simsbury, Connecticut and similar companies.

It is estimated that the cost of digging a pole hole in this manner would be approximately $4.50, which includes the following:

Expendable steel point	$ .25
Propellent Charge, squib and cap	1.50
Primacord (60 feet)	1.75
Labor	.50
Amortization	.50
TOTAL	$4.50

The amortization of the equipment is based on an estimated cost of $75.00 to be amortized at the rate of $.50 per hole or over a life span of 150 holes. The equipment other than the rod will probably be usable for several hundred holes; however, the rod may become bent and rendered useless if large rocks are encountered.

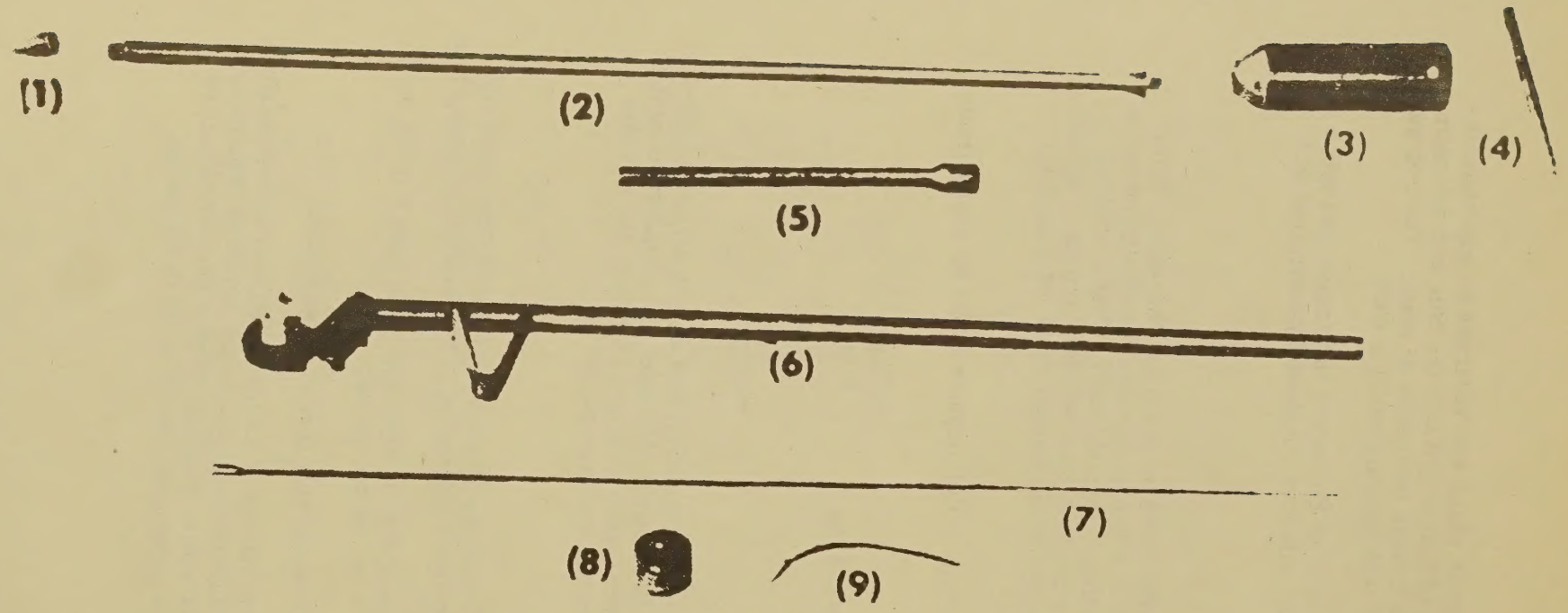
F. Conclusions

(1) There is little danger in setting up and firing the Blast Driven Earth Rod; however, the personnel using this device should be properly instructed in the handling of explosives.

(2) This technique will not compete with power driven auger type pole hole diggers used economically for quantity digging of holes in accessible ground.

(3) The device could be used only in terrain relatively free of large rocks.

Due to the nigh cost of materials and the limitations of its use, the Blast Driven Earth Rod does not appear to have any practical application in the construction of transmission and distribution lines at this time. Contact will be maintained with interested parties and possible manufacturers for the purpose of keeping posted on its development.



(1) Earth-rod point.
(2) Main rod.
(3) Firing chamber.
(4) Handle and starting rod.
(5) Extension rod.
(6) Extractor.
(7) Inserting rod.
(8) Propelling charge.
(9) Squib and fuse.

Figure 1 *Blast-driven earth rod equipment.*

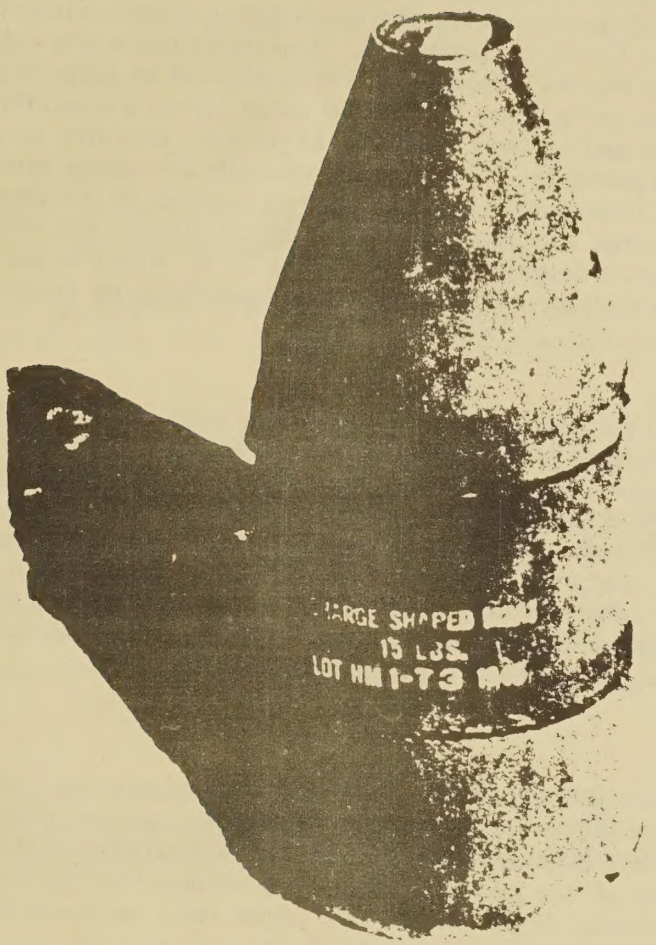


Figure 11. - M-2A3 shaped charge and stand-off shell assembled.

SHAPED CHARGE

A. Definition and Description

The shaped charge is a mass of explosive given a somewhat unusual configuration in order to achieve control over the nature of the forces occurring when the explosive is detonated. This investigation considered the three sizes of demolition-type shaped charges used by the U. S. Corps of Engineers. The three sizes are called the M-1, M-2A3 and M-3, of which the M-1 and M-3 were eliminated as inapplicable because the M-1 is too small to do the job and the M-3 is too large giving a considerable blast. The M-2A3, with a glass cone and a gross weight of 15 pounds, contains an explosive charge of 11.25 pounds of 50-50 pentalite. Although the charges are made with glass, steel or paper cones the glass cone seems to be preferred because of its abrasive effect. The dimensions of the charge are approximately 7 by 12 inches, and the stand-off will add about 5-1/2 inches to its height. The cost to the U. S. Army of the M-2A3 is approximately $7.33. The cost to civilian users would probably be higher.

B. Theory

The theory of the shaped charge might be explained in terms of the analytical methods of physical optics. The effect of the inverted cone is to act as a lens in focusing the expanding wave front of the explosive. A very substantial part of the energy expended by the explosion is directed perpendicular to the base of the inverted cone. The velocity of this directed wave front is very high, with considerable penetrating power. The depth of penetration and diameter of the hole will vary according to the kind of material being penetrated and the length of the stand-off. It has been determined that the stand-off should hold the charge approximately 2-1/2 feet from the ground to produce a pole hole when blasting in earth with the M-2A3 charge.

C. Discussion

On September 16, 1949, a group of REA personnel witnessed a demonstration of the shaped charge at Fort Belvoir, Virginia. One M-2A3 charge was detonated with the regular stand-off while simultaneously a second was detonated with the charge fixed approximately 2-1/2 feet off the ground. The group witnessing this explosion was behind a reinforced concrete shelter 300 to 400 yards away yet the blast could be felt thru the viewing slots.

The soil at this location would not have been much of a problem for ordinary hand digging methods. However, two more charges were similarly fired on a hill where the earth was rather hard and contained rock.

Another M-2A3 was fired in a heavily reinforced concrete wall which penetrated about 3 feet with a tapered hole of approximately 3-1/2 inches diameter entering and 2-1/2 inches diameter at the base. The holes in earth when using the charge fixed 2-1/2 feet from the ground appeared to be cylindrical.

The results of the five firings are tabulated below. The army engineers indicated that the dimensions were representative of the numerous experiments they have conducted under similar soil conditions.

D. Data

	Regular Stand-off		Charge Fixed 2-1/2 Feet off Ground	
	Penetration	Diameter	Penetration	Diameter
Ordinary Soil	3'	2'	6'	10'
Hard Earth Containing Rock	2-1/2'	1-1/2'	5-1/2'	9''
Reinforced Concrete	3'	3-1/2''	--	--
Armor Plate	1'	1-1/2"	--	--

The diameter of the holes in earth when the charge was fixed 2-1/2 feet off the ground would still have to be enlarged before a pole could be set.

It is estimated that the total net cost for blasting a pole hole in ordinary soil with the shaped charge and enlarging it to proper size would be approximately $11 which includes:

M-2A3	$9.00
(Demolitionist) 30 min. --$1.80/Hr	.90
Demolitionist Helper 30 min. --$1.20/Hr	.60
Enlarging hole 25 min. --$1.20/Hr	.50
TOTAL NET COST	$11.00

This is assuming a demolitionist and helper set up the charge, fire it, and inspect the hole within 30 minutes then move on to the next hole. It will take another laborer approximately 25 minutes to enlarge the hole.

E. Conclusions

All the major explosives companies, the U. S. Bureau of Mines and several other government agencies have investigated the commercial possibilities of shaped charges and all have concluded that shape charges are of value only in certain highly specialized applications.

Due to the high cost, the excessive blast effect and the dangers involved in use, the shaped charge at this stage of its development does not appear to have any practical application in the construction of transmission and distribution lines. However, it is intended to keep in touch with the manufacturers of the shaped charge and encourage further study and development by them.

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